CLAIMS

WHAT IS CLAIMED IS:

1. A three-dimensional construct comprising:

a polymeric matrix; and

a nanoparticle comprising a structure and a chemical functional group attached to the structure, wherein the nanoparticle has a diameter of about 5 nm to about 10 microns and is (a) coated with a monomolecular layer comprising biological information and (b) dispersed in the polymeric matrix at a density of at least 0.01 vol%.

2. The three-dimensional construct of claim 1, wherein the monomolecular layer is attached to the nanoparticle by at least one of covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces and ligand-substrate binding.

3. The three-dimensional construct of claim 1, wherein the monomolecular layer comprises a plurality of sequentially arranged monomolecular layers, wherein an innermost monomolecular layer is attached to the nanoparticle and an outermost monomolecular layer is external to the innermost layer, provided that (a) the innermost monomolecular layer is attached to the nanoparticle by at least one of covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces and ligand-substrate binding.

4. The three-dimensional construct of claim 1, wherein the plurality of monomolecular layers includes (a) the innermost monomolecular layer, (b) an intermediate monomolecular layer and (c) the outermost monomolecular layer, wherein the intermediate monomolecular layer is attached to at least one of the innermost monomolecular layer and the outermost monomolecular layer, provided that at least two of the plurality of the monomolecular layers are attached to each other by at least one of covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces and ligand-substrate binding.

5. The three-dimensional construct of claim 1, wherein the biological information is a member selected from the group consisting of a biomolecule, a polymer, and a bone substitute.

6. The three-dimensional construct of claim 5, wherein the biomolecule is a member selected from the group consisting of a bioactive polypeptide, a polynucleotide coding for the bioactive polypeptide, a cell regulatory small molecule, a peptide, a protein, an oligonucleotide, a nucleic acid, a poly(saccharide), an adenoviral vector, a gene transfection vector, a drug, and a drug delivering agent.

7. The three-dimensional construct of claim 6, wherein the bioactive polypeptide is a growth factor and such growth factor is a member selected from the group consisting of an epidermal growth factor, an acidic fibroblast growth factor, a basic fibroblast growth factor, a glial growth factor, a vascular endothelial growth factor, a nerve growth factor, a chondrogenic growth factor, a platelet-derived growth factor, a transforming growth factor beta, an insulin-like growth factor, a hepatocyte growth factor, a brain derived growth factor, bone morphogenic proteins and osteogenic proteins.

8. The three-dimensional construct of claim 5, wherein the polymer is a member selected from the group consisting of poly(carboxylic acid), poly(sulphonic acid), poly(lysine), and poly(allylamine).

9. The three-dimensional construct of claim 8, wherein the poly(carboxylic acid) is poly(acrylic acid).

10. The three-dimensional construct of claim 1, wherein the chemical functional group is a member selected from the group consisting of an amine group, a hydroxyl group, a carboxy group, an $-OSO_3H$ group, a $-SO_3H$ group, a –SH group, an –OCN group, a phosphorous group, an epoxy group, a vinylic moiety, a silane coupling agent, an acrylate, a methylacrylate, a metal alkoxy group, and derivatives thereof.

11. The three-dimensional construct of claim 5, wherein the bone substitute is a member selected from the group consisting of a calcium phosphate, a bioactive glass composition and a bioceramic.

12. The three-dimensional construct of claim 11, wherein the calcium phosphate is a member selected from the group consisting of hydroxyapatite, tricalcium phosphate, tetracalcium phosphate, and octacalcium phosphate.

13. The three-dimensional construct of claim 1, wherein the structure is an inorganic structure or an organic structure.

14. The three-dimensional construct of claim 13, wherein the inorganic structure is a member selected from the group consisting of an oxide, a nitride, a carbide, calcium silicate, calcium phosphate, calcium carbonate, a carbonaceous material, a metal, and a semiconductor.

15. The three-dimensional construct of claim 14, wherein the oxide is a member selected from the group consisting of Al_2O_3, TiO_2, ZrO_2, Y_2O_3, SiO_2, ferric oxide, ferrous oxide, a rare earth metal oxide, a transitional metal oxide, mixtures thereof and alloys thereof.

16. The three-dimensional construct of claim 15, wherein the metal is a member selected from the group consisting of aluminum, gold, silver, stainless steel, iron, titanium, cobalt, nickel, and alloys thereof.

17. The three-dimensional construct of claim 13, wherein the organic structure is a member selected from the group consisting of biodegradable polymers, non-biodegradable water-soluble polymers, non-biodegradable non-water soluble polymers, lipophilic moieties, and biopolymers.

18. The three-dimensional construct of claim 17, wherein the organic structure is a member selected from the group consisting of poly(styrene), poly(urethane), poly(lactic acid), poly(glycolic acid), poly(ester), poly(alpha-hydroxy acid), poly(ε-caprolactone), poly(dioxanone), poly(orthoester), poly(ether-ester), poly(lactone), poly(carbonate), poly(phosphazene), poly(phosphonate), poly(ether), poly(anhydride), mixtures thereof and copolymers thereof.

19. The three-dimensional construct of claim 1, wherein the polymeric matrix is a member selected from the group consisting of alginate, hyaluronic acid, poly(ethylene glycol), poly(vinyl alcohol), collagen, a peptide, poly(ethylene oxide)-b-poly(propylene oxide)-b-poly(ethylene oxide), poly(acrylic acid), and poly(isopropyl amide).

20. The three-dimensional construct of claim 1, wherein the three-dimensional construct is in a form of a gel, a cross-linked polymer, a liquid, a foam, a sponge, a mesh, a solid particulate, a fiber, or a layer.

21. The three-dimensional construct of claim 1, further comprising a cell dispersed within the polymeric matrix, wherein the cell is a member selected from the group consisting of chondroblast, chondrocyte, fibroblast, an endothelial cell, osteoblast, osteocyte, an epithelial cell, an epidermal cell, a mesenchymal cell, a hemopoietic cell, an embryoid body, a stem cell, and dorsal root ganglia.

22. The three-dimensional construct of claim 1, wherein the nanoparticle comprises silicon oxide, the chemical functional group comprises an amine group and the monomolecular layer comprises hydroxyapatite.

23. The three-dimensional construct of claim 22, wherein the monomolecular layer comprises at least one of a monomolecular layer of poly(acrylic acid) and a monomolecular layer of collagen as the intermediate monomolecular layer, provided that the monomolecular layer comprising hydroxyapatite is the outermost monomolecular layer.

24. The three-dimensional construct of claim 22, wherein the polymeric matrix is alginate, poly(ethylene glycol), poly(vinyl alcohol), collagen, a peptide, or poly(ethylene oxide)-b-poly(propylene oxide)-b-poly(ethylene oxide).

25. The three-dimensional construct of claim 1, wherein the nanoparticle comprises at least one of poly(lactic acid), poly(lactic-co-glycolic acid), and poly(anhydride) and the monomolecular layer comprises at least one of the monomolecular layer of poly(acrylic acid) and the monomolecular layer of collagen as the innermost monomolecular layer and the monomolecular layer of hydroxyapatite as the outermost monomolecular layer.

26. A method of presenting biological information to a cell or a tissue, the method comprising:

providing the three-dimensional construct of claim 1; and

contacting the three-dimensional construct with the cell or the tissue to present the biological information and thereby affecting the at least one characteristic of the cell or the tissue.

27. The method of claim 26, wherein the diameter, the biological information and the density are selected to affect the at least one characteristic of the cell or the tissue.

28. The method of claim 26, wherein the monomolecular layer is attached to the nanoparticle by at least one of covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces and ligand-substrate binding and when the plurality of the monomolecular layers is provided, the monomolecular layers are attached to each other by at least one of covalent bonding, hydrogen bonding, ionic bonding, Van der Waals forces and ligand-substrate binding.

29. The method of claim 26, wherein the biological information is a member selected from the group consisting of a biomolecule, a polymer, and a bone substitute.

30. The method of claim 26, wherein the nanoparticle comprises an inorganic structure or an organic structure.

31. The method of claim 26, wherein the at least one characteristic of the cell or the tissue is proliferation or differentiation.

32. The method of claim 26, wherein the nanoparticle comprises silicon oxide, the chemical functional group comprises an amine group and the monomolecular layer comprises hydroxyapatite.

33. The method of claim 32, wherein the monomolecular layer comprises at least one of a monomolecular layer of poly(acrylic acid) and a monomolecular layer of collagen as the

intermediate monomolecular layer, provided that the monomolecular layer comprising hydroxyapatite is the outermost monomolecular layer.

34. The method of claim 33, wherein the polymeric matrix is an alginate, poly(ethylene glycol), poly(vinyl alcohol), collagen, a peptide, or poly(ethylene oxide)-b-poly(propylene oxide)-b-poly(ethylene oxide).

35. The method of claim 33, wherein the hydroxyapatite is deposited onto collagen from an aqueous mixture comprising calcium nitrate tetrahydrate and ammonium phosphate at a molar ratio about 1.5 to about 2 and pH of about 7 to about 9.5.

36. The method of claim 35, wherein the molar ratio is equal 2.

37. The method of claim 26, wherein the nanoparticle comprises at least one of poly(lactic acid), poly(lactic-co-glycolic acid), and poly(anhydride) and the monomolecular layer comprises at least one of the monomolecular layer of poly(acrylic acid) and the monomolecular layer of collagen as the innermost monomolecular layer and the monomolecular layer of hydroxyapatite as the outermost monomolecular layer.

38. The method of claim 27, further comprising contacting the three-dimensional construct of claim 1 with an auxiliary surface prior to contacting the three-dimensional construct with the cell or the tissue.

39. The method of claim 38, wherein the auxiliary surface is a member selected from the group consisting of a polymer, a carbonaceous material, a wool, a glass, a ceramic, and a metal.

40. The method of claim 39, wherein the auxiliary surface is in a shape of a mesh, a fiber, a sheet, a sponge, a layer, a pattern, and a pre-formed object.

41. The method of making the three-dimensional construct of claim 1, the method comprising:

providing the polymeric matrix;

providing an unprocessed nanoparticle;

making the nanoparticle by contacting the unprocessed nanoparticle with a carrier of biological information to form the monomolecular layer; and

dispersing the nanoparticle in the polymeric matrix at the density of at least 0.01vol.% and thereby making the three-dimensional construct.

42. The method of claim 41, further comprising providing a hardening agent.

43. A nanoparticle comprising:

a structure, said structure is being a member selected from the group consisting of silicon oxide functionalized with a chemical functional group, poly(lactic acid), poly(lactic-co-glycolic acid), and poly(anhydride);

a monomolecular layer of hydroxyapatite; and

optionally a monomolecular layer of poly(acrylic acid) and/or a monomolecular layer of collagen, wherein the structure is coated with the monomolecular layer of hydroxyapatite and optionally with the monomolecular layer of poly(acrylic acid) and/or the monomolecular layer of collagen, provided that the monomolecular layer of hydroxyapatite is an outermost monomolecular layer.

44. The nanoparticle of claim 43, wherein the chemical functional group is a member selected from the group consisting of an amine group, a hydroxyl group, a carboxy group, an $-OSO_3H$ group, a $-SO_3H$ group, a –SH group, an –OCN group, a phosphorous group, an epoxy group, a vinylic moiety, a silane coupling agent, an acrylate, a methylacrylate, a metal alkoxy group, and derivatives thereof.

45. The nanoparticle of claim 43, further comprising an auxiliary surface, said auxiliary surface is a member selected from the group consisting of a polymer, a carbonaceous material, wool, glass, ceramic, and a metal, and wherein said carrier is in communication with the nanoparticle.

46. The nanoparticle of claim 46, wherein the auxiliary surface is in a form of a gel, a liquid, a foam, a solid, a fiber, a mesh, a sheet, a sponge, a pattern, and a pre-formed object.

47. A method of administering the nanoparticle of claim 45 to a cell, the method comprising:

providing the nanoparticle;

optionally providing an auxiliary surface, wherein the auxiliary surface is a member selected from the group consisting of a polymer, a carbonaceous material, a wool, a glass, a ceramic, and a metal and wherein the auxiliary surface is in communication with the nanoparticle; and

contacting the cell with the nanoparticle and thereby administering the nanoparticle.